

## 6. APPLIED TROPICAL CYCLONE RESEARCH SUMMARY

Part of the mission of the Joint Typhoon Warning Center is to conduct applied tropical cyclone research as time and resources permit. The purpose of this research is to improve the accuracy of operational forecasts. The following sections summarize the year's applied research projects which were completed or are still in progress.

### 6.1 RIDGE STATISTICS FOR NORTHWEST PACIFIC OCEAN (Cantrell, C. E., NPMOC/JTWC)

JTWC implemented a new forecast track review process for the 2000 western North Pacific Ocean tropical cyclone season that was adapted from the RSMC Tokyo procedures described in their Technical Review #2, JMA March 1998 by Nagata, Tahara and Muroi.

For this statistical review (Table 6-1), JTWC and CLIP forecast positions for TAU 24, 48 and 72 were stratified into four categories according to past 6 hour movement noted on the final best track (see Figure 6-1). As with the RSMC Tokyo procedures, a direction of movement between 180 and 319 degrees indicated that a cyclone was located equatorward of (below) the subtropical ridge. A direction of movement between 010 and 179 degrees defined the cyclone as being located poleward of (above) the subtropical ridge and the direction of movement between 320 and 009 degrees placed the cyclone "on" the subtropical ridge. Another category, "QS" (quasi-stationary), was included to account for cyclones that had a speed of advance of 3 kts or less.

Verification of forecasts in this manner is expected to provide JTWC with a better understanding of forecast biases within the four categories. Preliminary results for the 2000 season indicate a fast bias in the official JTWC forecast when the system was below the ridge (see Figure 6-2a). A similar fast bias is noted in the forecast when the system was above the ridge (see Figure 6-2c). When the system was on the ridge (Figure 6-2b) a westward bias is indicated in the JTWC forecast, indicating that systems recurved sooner than JTWC anticipated.

Table 6-1 summarizes a homogeneous comparison between JTWC and CLIP for tropical cyclones in 2000 with respect to stage of movement. Number of cases are given in parenthesis. % Improvement is defined as  $((\text{CLIP} - \text{JTWC})/\text{CLIP}) \times 100$ .

Table 6-1 JTWC and CLIP Forecast Errors (nm) for tropical cyclones in 2000 with respect to stage of movement.						
TIME	FORECAST	BELOW ON		ABOVE QS		ALL
24 Hour	JTWC	72 (268)	82 (124)	93 (161)	87 (54)	81 (607)
	CLIP	95 (268)	120 (124)	127 (161)	111 (54)	110 (607)
	% Improve- ment	24	32	27	22	26
48 Hour	JTWC	132 (223)	138 (95)	164 (108)	152 (44)	142 (470)

Table 6-1 JTWC and CLIP Forecast Errors (nm) for tropical cyclones in 2000 with respect to stage of movement.						
	CLIP	200 (223)	256 (95)	280 (108)	192 (44)	229 (470)
	% Improve- ment	34	46	41	21	38
72 Hour	JTWC	202 (197)	202 (65)	205 (71)	271 (33)	209 (366)
	CLIP	327 (197)	384 (65)	400 (71)	311 (33)	350 (366)
	% Improve- ment	38	47	49	13	40

## 6.2 BETA-TEST OF THE SYSTEMATIC APPROACH TO TROPICAL CYCLONE FORECASTING AID (SAFA) (Jeffries R. and Cantrell, C. E., NPMOC/JTWC)

The Joint Typhoon Warning Center (JTWC) conducted the first full operational beta-test of the Systematic Approach to Tropical Cyclone Forecasting Aid (SAFA), developed by Dr. Les Carr III, Naval Post Graduate School, Monterey, California, during the 2000 western North Pacific tropical cyclone season. SAFA is a computer based tropical cyclone (TC) forecast system designed to aid the Typhoon Duty Officer (TDO) in the review of model fields and in identifying possible systematic model errors.

Two forecast aids, the Non-Selective Consensus (NCON) and the Selective Consensus (SCON), are created by SAFA in conjunction with a model field review by the TDO. The NCON is a simple numerical consensus of all available dynamic model vortex tracks for each warning. The five models considered for the NCON are the Navy Operational Global Atmospheric Prediction System (NOGAPS), Geophysical Fluid Dynamics Laboratory Hurricane Prediction System - Navy version (GFDN), U.K. Met Office global model (EGRR), Japan Global Spectral Model (JGSM), and the Japan Typhoon Model (JTYM). If the TDO determines, after a thorough field review, that one or more of the models contains an error they have the option of removing that model(s) from the NCON thus creating an SCON.

A homogeneous comparison of the 24, 48 and 72-hour track errors for the JTWC official forecast, NCON, and SCON was conducted. However, only the 72-hour errors are discussed here. JTWC, NCON, and SCON track errors for 348 cases are presented in Figure 6-4.

Findings suggest that JTWC added value over NCON and SCON at 72 hours when NCON consisted of three or less models. However, JTWC was not able to add value to NCON when NCON consisted of 4 and 5 models. Figure 6-4 also highlights the fact that as the number of models available for NCON increases, the NCON track error decreases, especially once the fourth model is added. When all cases with one or more models are considered, the difference between JTWC and NCON is statistically insignificant.

Another important finding of this study centers around the creation of SCON. SCON was unable to improve on NCON when four and five models were available. Statistics also show that JTWC followed SCON closely in the four and five model cases. This points to the fact that SCON predictions were created too frequently, which in turn degraded the JTWC forecast when four and five models were available.

The initial test of SAFA was successful at JTWC, as the SAFA field review contributed to improved JTWC forecasts. This analysis, however, identified weaknesses in the initial user training and overall application of SAFA. Attention to these areas should result in JTWC being able to fully exploit the capabilities of SAFA as a method to continue improving TC track forecasts.

A more detailed review of the SAFA beta test at JTWC is being submitted to the AMS for publication in Weather and Forecasting.

### 6.3 JTWC OFFICIAL FORECAST AND MODEL INTENSITY STUDY (Jeffries R., Cox A.W., and Mallen K., NPMOC/JTWC)

JTWC implemented a program to baseline forecast errors as a starting point to future studies into the factors affecting intensity forecasting skill. The official forecast intensity errors were compared to the Statistical Typhoon Intensity Forecast (STIFOR) model intensity errors for the 2000 western North Pacific tropical cyclone season. Figure 6-5 displays the distribution and relative frequency of errors at the 24, 48 and 72-hour forecast.

Additionally, JTWC compared the submitted "bogus" intensity to the model initialization intensity for both the NOGAPS model and the GFDN model. It is noted that GFDN initializes close to the JTWC submitted intensity (Figure 6-6) in many instances, but the NOGAPS model appears to frequently

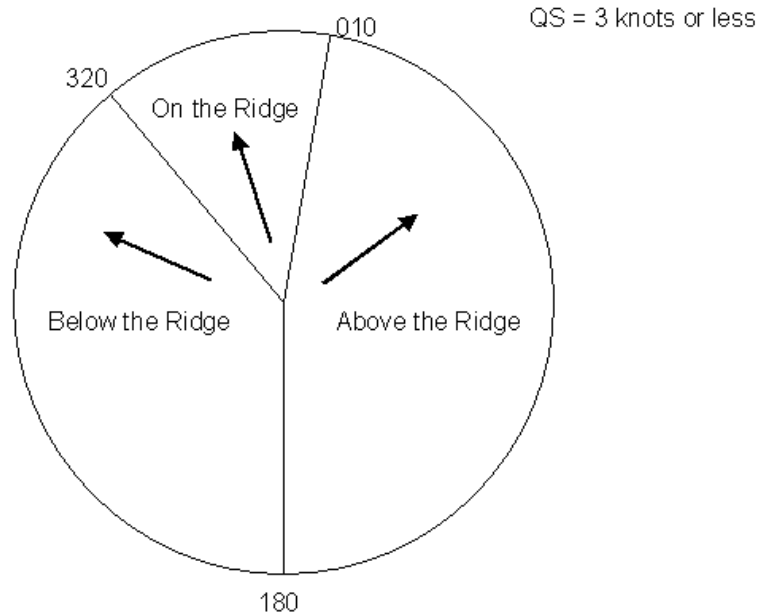


Figure 6-1. Graphical illustration of "Below", "On", "Above", and "QS". "Below" means that the direction of TC movement measured clockwise from the north is 180 to 319 degrees, "On" is 320 - 009 degrees, and "Above" is 010 to 179 degrees respectively. A fourth category "QS" is included to account for systems that are quasi-stationary (speed of advance of 3 knots or less).

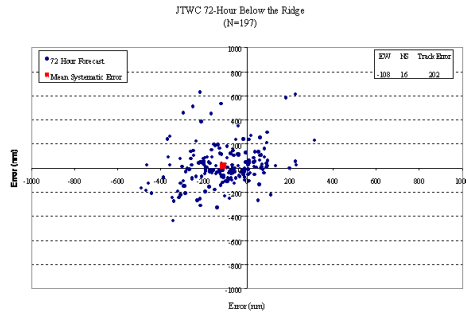


Figure 6-2a. Scatter diagram of center position errors of JTWC official forecasts at 72-hours for tropical cyclones (TC) in the western North Pacific during the 2000 season when the TC was below the ridge. Predicted TC centers are plotted in blue with respect to corresponding analyzed ones at the origin. Deviations upward (downward, leftward, rightward) from the origin indicate the predicted TC center is located north (south, east, west) of the analyzed one. The larger red square shows the mean (systematic) error, which is specified in nautical miles at the upper right hand corner of the graph. "EW" denotes the mean error in the "zonal" direction, "NS" denotes the mean error in the "meridional" direction, while track error is the mean track error.

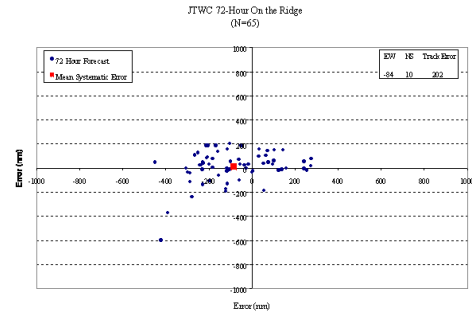


Figure 6-2b. Same as in Fig. 6-2a. except on the ridge.

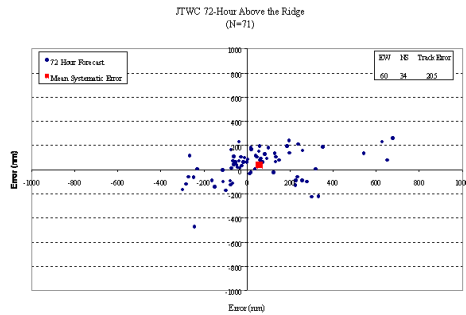


Figure 6-2c. Same as in Fig. 6-2a. except above the ridge.

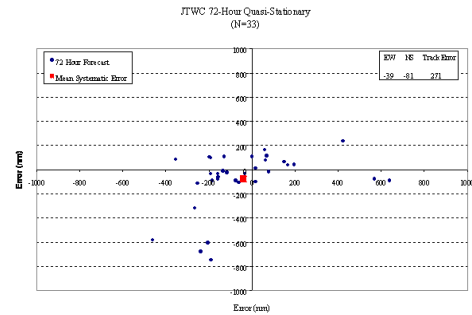


Figure 6-2d. Same as in Fig. 6-2a. except quasi-stationary.

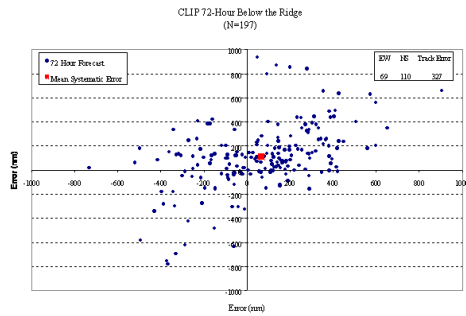


Figure 6-3a. Scatter diagram of center position errors of CLIP official forecasts at 72-hours for tropical cyclones (TC) in the western North Pacific during the 2000 season when the TC was below the ridge. Predicted TC centers are plotted in blue with respect to corresponding analyzed ones at the origin. Deviations upward (downward, leftward, rightward) from the origin indicate the predicted TC center is located north (south, east, west) of the analyzed one. The larger red square shows the mean (systematic) error, which is specified in nautical miles at the upper right hand corner of the graph. "EW" denotes the mean error in the "zonal" direction, "NS" denotes the mean error in the "meridional" direction, while track error is the mean track error.

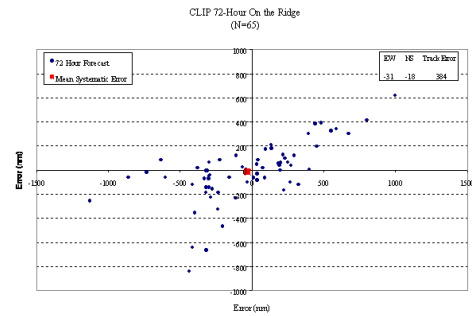


Figure 6-3b. Same as in Fig. 6-3a. except on the ridge.

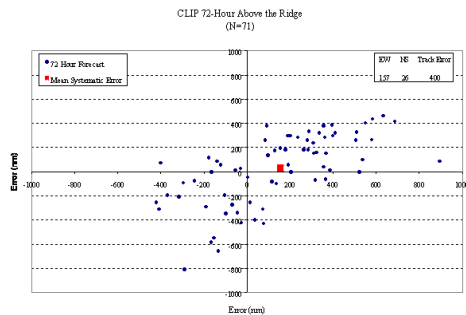


Figure 6-3c. Same as in Fig. 6-3a. except above the ridge.

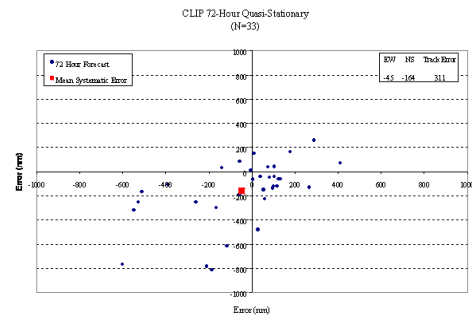


Figure 6-3d. Same as in Fig. 6-3a. except quasi-stationary.

under-represent the initial intensity, particularly in more intense systems (Figure 6-7). JTWC will continue to investigate and research the factors affecting intensity forecasting.

## 6.4 JTWC STORM ARCHIVE (LaFramboise D., Herron J., Schiber D. and Cantrell C., NPMOC/JTWC)

Storm reviews of the 34 western North Pacific storms that occurred during the 2000 tropical cyclone season have been created as part of the newly developed JTWC archive site. Each review includes all data available to JTWC during the time individual storms were being warned on. The archive site includes satellite data (AMSU, TRMM, SSMI, and Scatterometer), graphical displays of objective techniques and dynamic model vortex trackers, synoptic data, time intensity charts, warning graphics, warning messages, fix bulletins, and the objective techniques, best track and fix files from the Automated Tropical Cyclone Forecasting (ATCF) system. Each storm review also contains a 3-hourly satellite loop depicting the storm's life-cycle through infrared imagery. This data base will be continued for the 2001 Southern Hemisphere and Northern Hemisphere seasons and will be updated on a routine basis.

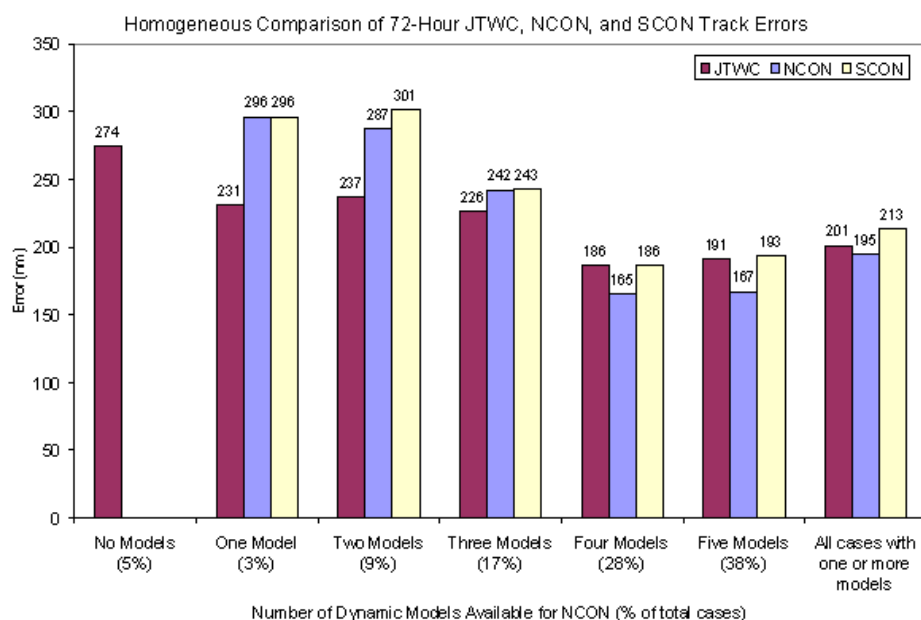


Figure 6-4. Homogeneous comparison of 72-hour mean forecast errors (NM) for JTWC, NCON, and SCON. Errors are categorized according to the number of models NCON contains.

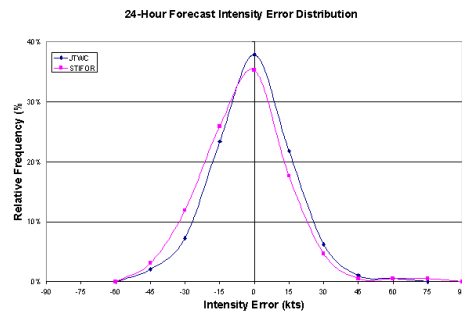


Figure 6-5a. The intensity error distribution and frequency for the 24-hour official JTWC forecast and the STIFOR model during the 2000 western North Pacific tropical cyclone season.

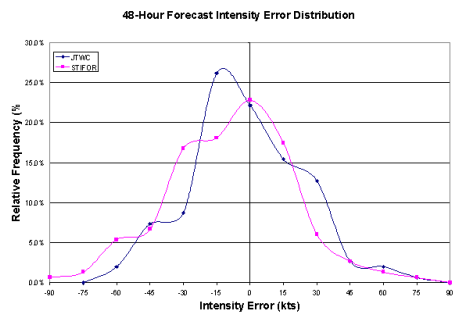


Figure 6-5b. The intensity error distribution and frequency for the 48-hour official JTWC forecast and the STIFOR model during the 2000 western North Pacific tropical cyclone season.

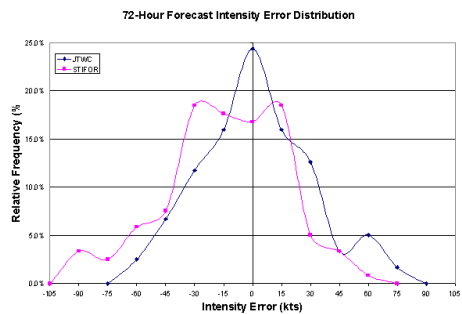


Figure 6-5c. The intensity error distribution and frequency for the 72-hour official JTWC forecast and the STIFOR model during the 2000 western North Pacific tropical cyclone season.

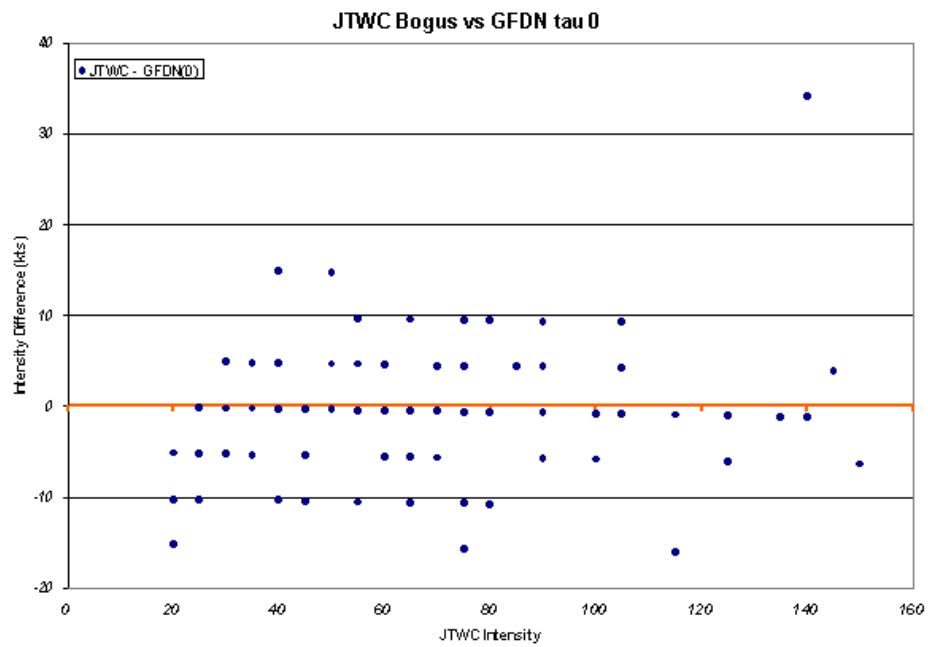


Figure 6-6. Intensity difference between the submitted JTWB intensity and the GFDN analysis.

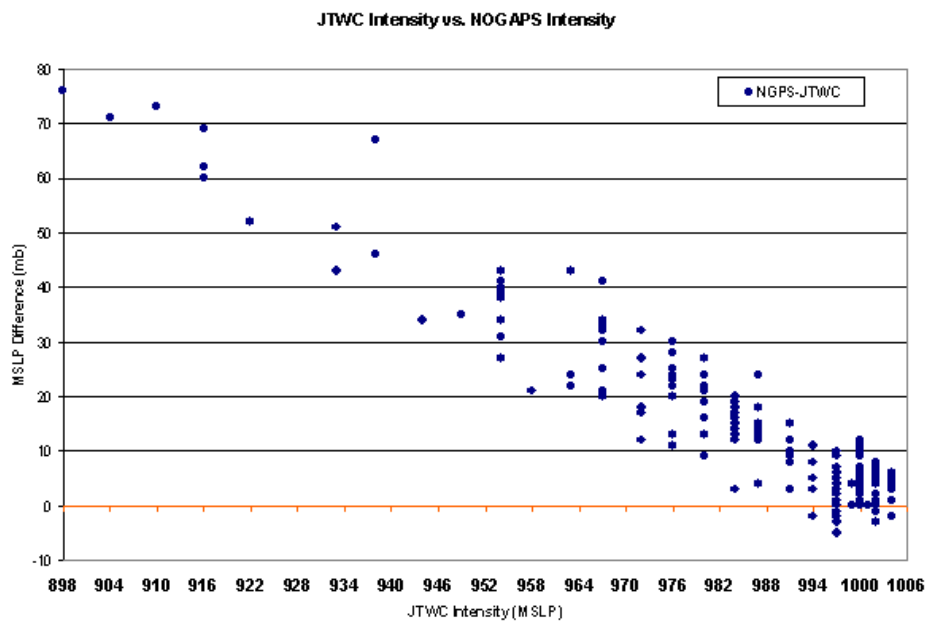


Figure 6-7. Intensity difference between the submitted JTWB intensity and the NOGAPS analysis.

A data base of all available GOES-10, GMS-5 and MET-5 full disk visible, infrared, and water vapor imagery for all of 2000 and 2001 (year-to-date) has also been included as part of the archive. This data base is updated continuously.

The final section of the archive includes 6-hourly surface synoptic charts and 12-hourly upper air charts for 2000 and will also be updated on a continuous basis.

Access to this site will be granted on a case-by-case basis. Please contact the JTWC technical advisor at JTWCTA@npmoc.navy.mil.

## **6.5 VALIDATION OF BEST TRACK DATA (Chu J. and Sampson B., NRL; Fukada,E. Schiber D. and Levine A., NPMOC/JTWC)**

A systematic cross-validation of the western North Pacific (1950-1998), the north Indian Ocean (1970-1998) and the Southern Hemisphere (1985-1998) best track data contained in the JTWC archive database and Annual Tropical Cyclone Reports (ATCR) is being performed to eliminate errors noted in previous years and ensure the archive better represents the published best-tracks.

The team will visually compare and document differences between JTWC archive data and JTWC ATCRs, check best-tracks against other sources, such as the Hong-Kong Observatory, and Charlie Neumanns HURISK program (published in 24th Conference on Hurricanes and Tropical Meteorology), agree to changes in the archive, and include the final corrections into the JTWC archive database.

The final step will be a posting of the corrections to the JTWC web site and into the ATCF system database. A written report will serve as documentation of the results.